to your readers a recently discovered regular secular period in one of the meteorological elements of Calcutta; a period too, (though this is at present a matter of secondary importance) which decidedly favours the reverse hypothesis to that entertained by Prof. Smyth regarding the variation of solar energy. The following figures have been worked out, and communicated to me, by Prof. S. A. Hill of Allahabad, and he has I believe given his conclusions from them and similar results, in a recent number of the Austrian *Zeitschrift für Meteorologie*, which, however, I have not as yet seen.

The table which follows, shows the annual range of mean monthly barometric pressure at Calcutta, from 1840 to 1878 inclusive, bloxamed in a series of eleven years, the average length of a sun-spot cycle, beginning with the year of sun-spot minimum.

Calcutta.

Years of cycle.		Annual range of mean monthly pressure in decimals of an inch.
11	Years of minimum sun-spot	·530
1		·549
2		·538
3		·510
4		·499
5	Years of maximum sun-spot	·502
6		·502
7		·500
8		·506
9		·512
10		·514
11		·530

The figures for Roorkee, from 1864 up to the present time, give a similar result. So far then as we have gone at present in India, we find years of few sun-spots characterised by higher temperatures, greater wind-velocity, and greater range of barometric pressure than those of many spots. The terrestrial effects of a "languid" sun are therefore strikingly like those of an unusually *hot* sun. E. DOUGLAS ARCHIBALD

Grosvenor House, Tunbridge Wells, October 18

Colour-Blindness

WHILE the subject of colour-blindness is before your readers, the present seems a favourable opportunity for calling attention to a method of experimenting which I used some years ago[1] for testing normal vision, and which seems, if applied to colour-blind eyes, likely to be capable of telling us something of the nature of that peculiar form of colour sensation.

When I made my experiments on normal eyes I intended extending the investigation to colour-blind eyes, but most unfortunately I was quite unable to find a true case of colour-blindness. All the cases reported to me proved, on examination, not to be produced by colour-blind eyes at all, but to be the result of want of observation and knowledge, as they all could distinguish between different colours, when placed alongside each other, and could also arrange the different colours, though when shown colours separately they made dreadful mistakes in naming them.

The method adopted in my experiments was as follows:—A prismatic spectrum was produced by passing a beam of light through a slit, a lens, and a bisulphide of carbon prism, in the usual way. The spectrum was thrown on a large number of rectangular reflectors, placed close to each other, and all capable of being moved so as to throw the light reflected from them to any point on a screen in front. With this apparatus we have the means of testing what colours can be produced by mixing others, and what colours cannot be so produced—by throwing the light reflected by one of the reflectors on the screen and trying if it is possible to match it by combinations of rays from other parts of the spectrum. It is found that for the normal eye the same sensation which is produced by the yellow part of the spectrum can be produced by mixtures of rays from the red and green parts, and also by rays from parts lying between these colours and yellow. And that the sensation which we call blue, can be produced by the blue part of the spectrum or by mixing rays from each side of the blue, that is by mixtures of violet and green. The yellow and blue are, however, the only two parts of the spectrum, the sensation of which can be imitated by combining rays from other parts of the spectrum. We cannot, for instance, produce green by any mixtures of rays from other parts of the spectrum. The red and the violet sensations are also incapable of being produced by mixtures.

[1] *Proceedings* of the Royal Scottish Society of Arts, 1871-2.

These results are, to a certain extent, a proof of the threefold nature of our colour sensations. And they also show us that it is a mistake to talk of colours as simple and compound, as all the colours we find in nature are compounded of rays of many different rates of vibration. The difference between different colours is, those of one rate of vibration, say those of the D-line, even though absolutely pure, are capable of exciting a compound sensation, namely, the red and green, while mixtures of rays from each side of the line B, are only capable of giving rise to a simple sensation—namely, the red.

Supposing this three-sensation theory to be true, then there are certain conceivable variations of it which would give rise to colour-blindness. The blindness, for instance, might be produced by two of the three sensations being very similar. This does not seem improbable when we consider that, to any two persons, with normal eyes, the different colours will not necessarily appear equally different, and that, in the same normal eye, the different simple sensations are not separated by equal differences from each other. That is, supposing our sensations of the three primary colours to be represented by the three angles of a triangle, then the triangles, if drawn to the same scale, would be of different sizes for the eyes of different persons, and for almost all eyes the triangles would not be equilateral. The side between the green and the violet would be shorter than the other two, because the sensation of green is more similar to the sensation of violet, than green is to red or red is to violet. Or we might conceive the colour-blindness to be produced by the different sensations being irregularly, or by being too widely, distributed over the spectrum. If, for instance, the green sensation extended into the red part of the spectrum and the red sensation into the green part, that is, if the same rays excited both sensations in the same proportion, not only in certain parts, but throughout their entire range, then an eye, so constructed, would be incapable of distinguishing red from green. Another way in which colour-blindness might result, is by an absence of one of the three sensations.

It is impossible, without experimenting on colour-blind eyes, to say whether any of these, or some other, is the true cause of colour-blindness, and it is very desirable that some one, accustomed to make colour observations, would test colour-blind eyes in the way suggested; it would settle at once, for the particular eyes experimented on, whether they are badly defined trichroic eyes or are dichroic. If the eyes are dichroic, then, clearly, there will be only one part of the spectrum, the sensation of which can be produced by mixtures of rays from other parts, and not two as in trichroic vision.

Besides the apparatus described many others, more accurate, might be constructed, but the great advantage of this arrangement is, that it is suited for testing eyes not accustomed to make accurate observations or to be trammelled with elaborate apparatus. If Prof. Pole was to undertake the investigation, he could easily devise some simple apparatus to suit the experiments which, in his hands, would probably give some valuable results.

Darroch, Falkirk, October 7 JOHN AITKEN

Subject-Indexes to the Royal Society Catalogue of Scientific Papers

As you have opened your columns to Mr. Garnett's valuable paper on "Subject-Indexes to Transactions of Learned Societies," you will perhaps allow me to make a suggestion in regard to the proposal contained in it. The initial objection to Mr. Garnett's scheme appears to me to be that the work he suggests will really be as large as the original catalogue, and, in fact, the same work in a new order. Even were it possible to get the money (probably little short of 10,000*l.*), the question would naturally arise whether or no the result was likely to be worth this great outlay. Moreover, the plan proposed by Mr. Garnett would not meet the great difficulty of compilation, which consists in the getting together of papers treating of identical subjects, but written with various titles by different persons. This would make it necessary to employ experts in each subject, and also a general practical editor for the whole, under whose eye all entries must pass. I cannot help thinking, therefore, with Mr. J. B. Bailey (p. 580), that the titles of the papers would have to be generally ignored.

If the index were made as indexes to catalogues are usually compiled, it might be got into at least a third of the space of the

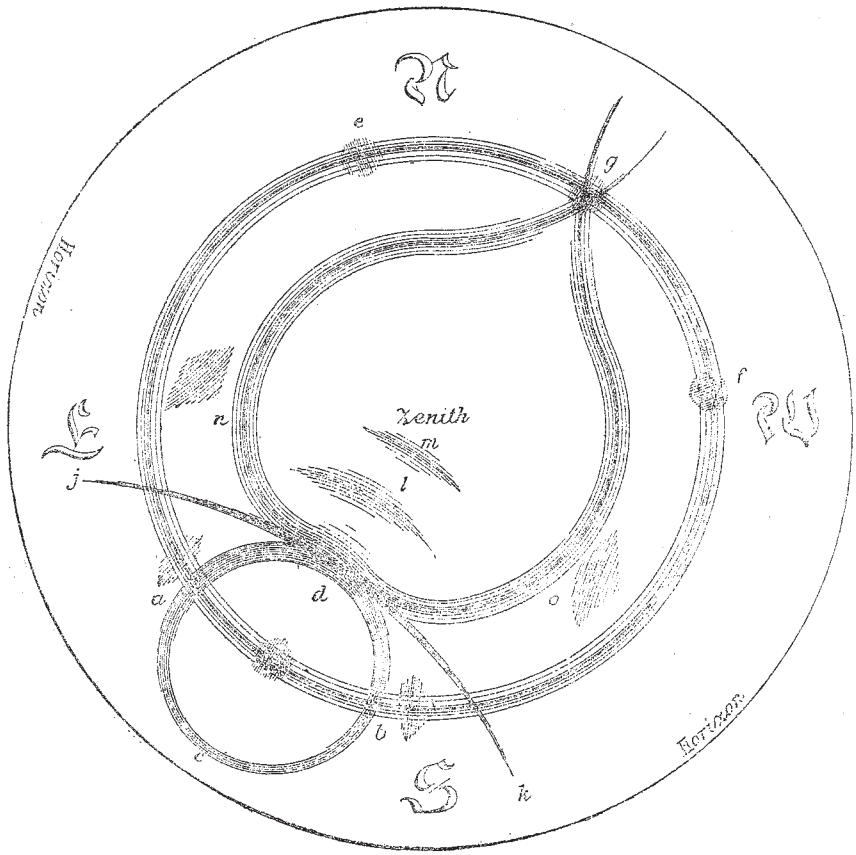
original book, perhaps into a sixth. As to the need of such an index there cannot be two opinions. If, however, a fuller classified catalogue, such as is proposed by Mr. Garnett, be thought necessary, would it not be better to make it in the form of a series of indexes of separate subjects? The day for great encyclopædic works is nearly past, and as the astronomer cares little for the papers of the zoologist, and would find them only in his way, so both the zoologist and the astronomer would wish to have his own subject in a distinct volume.

This leads me to the chief point of this letter, which is to draw attention to the work that is already being done. I have received a letter from Prof. Holden, of the United States Naval Observatory, in which he announces to me, as Secretary of the Index Society, his intention of making an index to all the entries referring to astronomy in the Catalogue of Scientific Papers, and also informs me that Prof. Abbe, of the United States Signal Service and Weather Bureau, has a complete card catalogue of the meteorological entries in the Royal Society Catalogue. Probably other workers have done the same for other subjects. This is, I think, the best use to make of the Catalogue of Scientific Papers, which is of immense value, in the first place as a catalogue of authors, and secondly, as a collection of authentic documents from which a series of subject-indexes may be drawn.

Society of Arts, October 28 HENRY B. WHEATLEY

Solar Halo

I INCLOSE a sketch of a remarkable solar halo and parhelia which I observed here on the 22nd ult. As I happened to have facilities at hand, I was enabled to take the dimensions and position of the various features of the phenomenon with sufficient accuracy. These appearances were first seen by me at 9.30 A.M., and continued nearly constant in brilliancy till about 10 A.M., when they gradually faded, and at 10.30 hardly anything was visible except the outer ring, *a b e f g*, which continued till 1 P.M. At 9.45 the inclosed sketch was made and the measurements taken. The sun had then an altitude of about 30°, and was very misty and indistinct. It was surrounded by an ordinary solar halo of about 45° diameter; and through the sun passed another perfectly unbroken circle whose centre was exactly at the zenith. This circle had no colour and was similar in character to the ordinary concentric solar halo; its angular diameter was 120°; concentric with this was another circle of 78° diameter. This inner circle was not quite perfect at the point where the circle, *a b c d*, touched it; it was slightly distorted, and through the same point (*d*) passed a portion of another circle of larger radius, *j k*. The junction of these three circles formed a beautiful spectrum, and was the most brilliant



part of the whole phenomenon. The inner circle was also imperfect on the side opposite the sun, when it branched off in two opposite curved tails, which, crossing the outer circle at the same spot, *g*, formed a mock sun. Two other mock suns were to be seen at *e* and *f*, 50° to each side of *g*. These three mock suns were all colourless, but at *a* and *b*, not on the concentric halo, but about 2° outside it, were two beautifully coloured mock suns, each being a perfect spectrum.

Finally, two portions of coloured circles were seen at *l* and *m*, with the concave side towards the sun, and two others at *n* and *o*, with their convex sides towards the sun, but in every case (both of circles and mock suns, *a* and *b*) the red colour was nearest the sun and the blue farthest from it.

I may mention, to give an idea of the brilliancy of the phenomenon, that many persons mistook one or other of the coloured bands for rainbows, and in one case one of the mock suns was supposed to be the sun itself (the sun happening to be hid from the observer by some adjacent buildings).

Dublin, October 11 HOWARD GRUBB

Karl Friedrich Mohr

IN your notice on the late Karl Friedrich Mohr there is no mention made of one of his most remarkable works, "Die Geschichte der Erde," the first edition of which appeared in 1866. In it he takes up what he considers entirely new ground